State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Engineering Division
Honolulu, Hawaii 96813

August 28, 2009

Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

APPLICATION FOR A DLNR DAM SAFETY CONSTRUCTION/ALTERATION PERMIT PERMIT NO. 34 - OPAEULA RESERVOIR NO. 1 (HI00018) RESERVOIR REPAIR, HALEIWA, OAHU

The Engineering Division hereby submits an application for your authorization and approval for issuance of a Dam Safety Construction/Alteration Permit for the reservoir repair at the Opaeula Reservoir No. 1, to Kamehameha Schools, Pursuant to Chapter 179D Hawaii Revised Statutes and Chapter 190 Hawaii Administrative Rules.

APPLICANT:
Mr. Kaeo Duarte
Kamehameha Schools
567 South King Street, Suite 200
Honolulu, HI 96813

LANDOWNER:
Same as applicant

SUMMARY OF REQUEST:
Application for a Dam Safety Construction/Alteration Permit for repair of the Opaeula Reservoir No. 1 Dam (HI00018), Haleiwa, Oahu, TMK: (1)6-2-011:001 See Exhibit 1.

LOCATION: Haleiwa, Oahu. See Exhibit 2.

BACKGROUND:
A preliminary application for the repair of the Opaeula Reservoir No. 1 Dam was filed on June 19, 2008 by the dam owner, Kamehameha Schools. During an inspection conducted on April 4, 2009 by the Army Corps of Engineers, the dam was found to be in fair condition and deficiencies were listed for the owner to carry out corrective actions. Opaeula Reservoir No. 1 was constructed in 1910 for irrigation purposes. It is the largest reservoir and it provides water via tunnels and ditches to various smaller reservoirs downstream, including Opaeula 2 Reservoir and Opaeula 15 Reservoir.

DESCRIPTION:
The Opaeula Reservoir No. 1 is impounded by an earthen dam. The reservoir level is controlled by outlet works and a spillway tunnel. The reservoir covers an area of approximately 6.5 acres at full

stage. Operating depth is normally between 58 and 60 feet. The maximum reservoir impoundment volume is estimated at 400 acre-feet (130.68 million gallons). The existing outlet work capacity is unknown. The dam is an earthen structure with a crest length of approximately 250 feet and a maximum crest height of 71 feet. The width of the crest varies from 10 to 15 feet.

The engineering assessment of the existing dam shows deficiencies in spillway capacity and slope stability. To mitigate the deficiency of the spillway capacity, four (4) 48-inch diameter pipes are proposed to be installed in the right abutment. When used in conjunction with the existing spillway, there will be sufficient discharge capacity to accommodate the Probable Maximum Flood (PMF). The downstream face of the embankment will be stabilized with an earthen buttress which is composed of onsite earth material with a boulder riprap toe.

The outlet controls for the two existing 18-inch pipes will be upgraded by the removal of the existing downstream control valves and the installation of a new gate control in the existing outlet vault box located at the dam crest. See Exhibit 2 and 3.

REMARKS:
Kamehameha Schools and its consultants, Oceanit, Inc., have completed a basis of design, plans and requests for the approval of a dam safety construction/alteration permit.

The Department along with their consultant, Gannett Fleming, Inc., has reviewed the plans and concluded that it is sufficient for its intended purposes. Staff recommends approval of this permit application. See Exhibit 4.

RECOMMENDATION: That the Board:

1. Authorize the approval and issuance of the Dam Safety Construction/Alteration Permit for this project; and
2. Direct the Chairperson to issue a dam safety permit for the repair of the Opaeula Reservoir No. 1 (DLNR Dam Safety Construction/Alteration Permit No. 34) subject to such other terms and conditions as may be prescribed by the Chairperson to best serve the interests of the State.

Respectfully submitted,

ERIC T. HIRANO
Chief Engineer

APPROVED FOR SUBMITTAL:

LAURA H. THIELEN, Chairperson

Exhibit(s):
1 Owner Permit Application
2 Design Report pages and Location Plan
3 Construction Drawing pages and site plan and profile (to be provided at Board meeting)
4 DLNR Consultant Review (to be provided at Board meeting)

State of Hawaii
BOARD OF LAND AND NATURAL RESOURCES
Department of Land and Natural Resources
Engineering Division

APPLICATION FOR APPROVAL OF PLANS AND SPECIFICATIONS FOR CONSTRUCTION, ENLARGEMENT, REPAIR, ALTERATION, OR REMOVAL OF A DAM

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Date of Application: June 12, 2008

Applicant:
Name: Kaeo Duarte Firm / Company: Kamehameha Schools, Land Asset Division

Mailing Address 567 South King Street, Suite 200, Honolulu, HI 96813

Telephone: 523-6200 Fax: 523-6374 Email: kaduarte@ksbe.edu

The Applicant hereby applies to the Board of Land and Natural Resources for the approval of the attached plans and specification for the Opaeula Reservoir No. 1 – Dam Improvements (construction, etc.) in accordance with Chapter 179D HRS (as amended by Act 262, SLH 2006), and subject to the provisions, conditions, and limitations of the current Hawaii Administrative Rules and various DLNR dam safety guidelines.

Accompanying this application is:	(please check)
1. Filing fee ($25.00) (Waived for government agencies)	x
2. Three (3) copies of the Detailed Cost Estimate	x
3. Three (3) copies of the Final Design Report	x
4. Three (3) copies of the Plans	x
5. Three (3) copies of the Specifications	x
6. Proposed Construction Schedule	x
7. Supporting documents:	
a. Drainage Report	x
b. Geotechnical Exploration & Evaluation Report	x

NAME OF STRUCTURE: Opaeula Reservoir No. 1 - Dam HI 018

DAM OR RESERVOIR LOCATION: approximately 5.5 miles east-southeast of Haleiwa town on the Island of Oahu, Hawaii (21° 34.4' N, 158° 1.8' W)

Island: Oahu Tax Map Key: 6-2-11:01

Attach USGS topographic map (scale 1" = 2000') and property tax map (showing location access to site, proposed work) - See attached location map.

State Land Use District: X Agriculture ___ Urban ___ Rural ___ Conservation

BRIEF DESCRIPTION OF WORK TO BE PERFORMED
The proposed dam improvement work includes construction of a buttress toe to increase dam stability to met both Federal and State guidelines; construction of a new primary spillway structure; relocation and modification of the outlet control facilities; rehabilitation of existing outlet piping; installation of monitoring wells and monitoring instrumentation.

Exhibit 1

TECHNICAL INFORMATION: DLNR-Dam Safety-Sheet 2

1. Drainage Area 0.00625 sq. miles or 4.0 acres

2. Classification of Dam Small

3. Type of Structure Earth fill embankment

4. Elevation-Area-Capacity Data:

Existing conditions	Elevation	Surface Area (acres)	Total Storage Volume (acre-feet)
Natural Streambed	~917'		
Primary Spillway (exist.)	~987'		188 ac-ft
Secondary Spillway	No secondary spillway		
Top of Dam	1000		
Design Water Level	~987	9.70	188 ac-ft
Invert of Drain	~952		

Elevations are assumed (feet)

5. Spillway Details (Type, Dimensions, Material)
   Primary: Concrete Lined tunnel 7'x 9' (existing)
   Secondary: none

6. Purpose of Structure : Currently used for irrigation purposes
   (water supply, irrigation, recreation, real estate development, etc.)

7. Attach rainfall and stream flow records, and flood-flow records and estimates (as accurately as may be readily obtained)
   No rainfall and stream flow records are available

ADDITIONAL INFORMATION

1. Primary Owner Contact (if different from applicant) n/a
   Owner Company or Entity: Kamehameha Schools
   Mailing Address 567 S. King Street,Suite 200
   Telephone: 534-3866 Fax: 523-6374 Email: kaduarte@ksbe.edu

2. Registered Hawaii Professional Engineer who prepared the plan Derrick C. Elfalan
   Mailing Address 828 Fort Street Mall, Suite 600; Honolulu, HI 96813
   Registration No. 5448-C / expires 04/30/2010
   Telephone: 531-3017 Fax: 531-3177 Email: delfalan@oceanit.com

3. Additional Technical Consultants:
   ParEn, Inc. dba Park Engineering – Surveyors
   YogiKwong Engineers, LLC – Geotechnical Engineers
   KSF, Inc. – Structural Engineers

3. Registered Professional Engineer to be responsible for inspection during construction
   Derrick C. Elfalan

4. Contractor (If known) To be selected
   Mailing Address
   Telephone: Fax: Email:

5. List all other permits applications submitted to other governmental agencies:

Grading permit – City & County of Honolulu

Following permits are not required:

Commission on Water Resource Management	Stream Channel Alteration Permit (SCAP)
Commission on Water Resource Management	IIFS
County	SMA
CZM	CZM Federal Consistency Review
Division of Historic Preservation (HP), DLNR	Agency and Public Review (exist. structure)
DLNR	CDUA
DOH Clean Water Branch	Section 401
DOH Clean Water Branch	NPDES- NOI
U.S. Army Corps of Engineers	Section 404

6. Anticipated effect of proposed structure on natural environment: No impacts or changes on the natural environment are anticipated from the results of the proposed dam improvements. Propose improvements will increase dam operational safety, add additional mitigative improvements to minimize and control onsite erosion and effectively improve downstream water quality.

7. List all other parties that have ownership or other interest on the parcels where the dam and reservoir are located and identify their interest in the property. The Owners herein listed below concur with the work proposed within this application by the applicant and by his/her signing hereto, the owner of the land extends to the Board of Land and Natural Resources, and its designated representatives, a right-of-entry onto the project site to conduct any investigations or inspections required in compliance with the provisions of Chapter 13-190, Hawaii Administrative Rules. (Submit additional copies of this sheet should there be more owners)

Owner:

Kamehameha Schools
567 South King Street
Honolulu, HI 96813

Thomas K. Duarte	567 S. King St., Hon. HI 96813 / 100%
(Signature of Owner)	(Address / Interest in Dam or Reservoir)
_____	_____
(Signature of Owner)	(Address / Interest in Dam or Reservoir)
_____	_____
(Signature of Owner)	(Address / Interest in Dam or Reservoir)
_____	_____
(Signature of Owner)	(Address / Interest in Dam or Reservoir)
_____	_____
(Signature of Owner)	(Address / Interest in Dam or Reservoir)

I, Thomas Kaeo Duarte, the applicant, hereby certify that the information herein is true and factual to the best of my knowledge. Signing below indicates that the applicant understands that, if the permit requested is granted by the Board of Land and Natural Resources, the proposed work is to be initiated and completed within two (2) years of the approval date, unless specifically permitted in the approved permit terms and conditions.

Thomas K. Duarte
(Signature of Applicant & Title)
Water Resources Manager

Date: June 10, 2008

ENGINEERING REPORT

Opaeula Reservoir No. 1 Dam Improvements

Waialua, Haleiwa, Oahu, Hawaii

Prepared for:

Kamehameha Schools

Prepared by:

828 Fort Street Mall
Suite 600
Honolulu, HI 96813

June 2008

Exhibit 2

1.0 Introduction

An assessment was conducted to evaluate the project dam, commonly referred to as the Opaeula 1 Reservoir Dam, for conformance to State of Hawaii dam safety requirements. This report presents the engineering design evaluation and analysis for the Opaeula 1 Reservoir Dam. Included are the findings from investigations and recommended improvements for the dam. A topographic survey and several site investigations were conducted to verify existing field conditions.

A Phase II study for the dam by Ernest K. Hirata & Associates, Inc. (EKH), dated September 8, 1998, presented a hydrological study, spillway analysis, and embankment stability analysis. This study was used as a resource in the investigation. The previous hydrological analysis did not determine the PMF. A flood analysis using both the probable maximum precipitation (PMP) and 100-year storm was conducted to assess spillway capacity requirements.

2.0 Background

The Opaeula 1 Reservoir Dam was constructed in 1910 for irrigation purposes. Documentation on the original design, construction plans, and construction methods are unavailable. The design documents were destroyed in a fire at the Waialua Sugar Company offices during the late 1970s. The Opaeula 1 Reservoir Dam is the largest and furthest mauka of the Opaeula dams (1, 2, and 15). It provides water via tunnels and ditches to various smaller reservoirs downstream, including Opaeula Reservoir Nos. 2 and 15.

The Opaeula 1 Reservoir Dam is located approximately 5.5 miles east-southeast of Haleiwa town on the Island of Oahu, Hawaii (21° 34.4' N, 158° 1.8' W). Access to the Opaeula 1 Reservoir Dam is via a private roadway which begins in Haleiwa town. See Figure 2-1 for a location map.

2.1. Topography/Bathymetry

A topographical survey was conducted by ParEn Inc. in January 2007 which covered the reservoir dam, adjacent abutment, spillway, downstream dam face, and toe of the dam. The elevations of the survey were based on an assumed elevation at the dam crest of 1,000 feet. See Figure 2-2 for the topographical survey map.

The Opaeula 1 Reservoir is currently in service and impounding water. A bathymetric survey was conducted by Oceanit in May 2007. The bathymetric survey was combined with the topographic survey as shown in Figure 2-2.

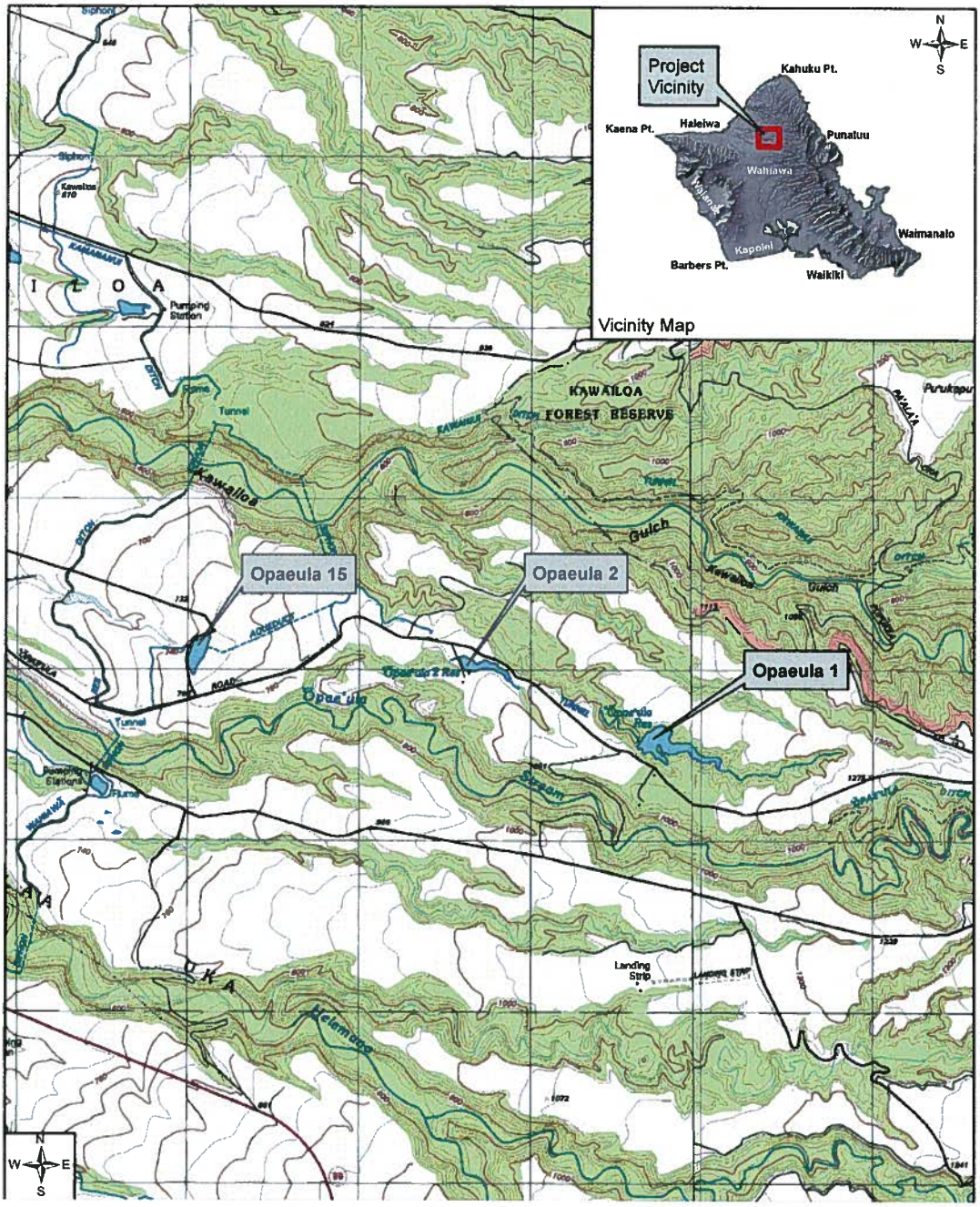

Figure 2-1: Location Map

2.2. Soil Characteristics

A geotechnical exploration of the Opaeula 1 Reservoir Dam was conducted by Yogi Kwong Engineers (YKE) in January 2007. YKE conducted groundwater testing, borings, and soil sampling in the dam and abutment area. In addition, YKE also conducted a slope stability analysis of both dam faces. The YKE geotechnical report was used as a resource for the engineering analysis.

The dam is comprised of two major soil units - embankment fills and completely weathered basalt. Based on the YKE report and the 1998 EKH report, the dam embankment is constructed of mottled brown to mottled red and grayish brown elastic silt with weathered rock fragments. The embankment fills were encountered in borings on the dam crest up to depths of approximately 59 feet below ground surface. On the downstream toe, the borings show embankment fill at a depth of 5 feet below ground surface.

The embankment fills are completely underlain by completely weathered basalt. The completely weathered basalt encountered in the borings was described as clayey silt with weathered rock fragments and stiff to very stiff with low shrink-swell potential.

2.3. Hydrology

The Opaeula 1 Reservoir is located on the leeward side of the Koolau Mountain range, 5.5 miles inland of the coastal town of Haleiwa. The reservoir receives water from the Opaeula Ditch Tunnel, which is fed by the Opaeula and Kawaiiki streams in the Kawailoa Forest Reserve. Located in a side branch of the Kawailoa Gulch, the reservoir feeds into the Anahulu River, which drains into the ocean at Haleiwa Harbor.

Steep banks surround the Opaeula 1 Reservoir and the gulch leading into it. These banks are densely vegetated with grasses, thick ferns, low-lying shrubs and trees. The watershed area above these banks is gradually sloping rangeland vegetated with thick grass and small shrubs. The area of the watershed tributary to the reservoir is 162 acres.

A hydrologic analysis (see Appendix A) was conducted, in which the maximum runoff produced by the most severe combination of hydraulic and meteorological conditions reasonable for the Opaeula 1 Reservoir was determined. This flow is the PMF and it was determined to be 1,950 cfs for the Opaeula 1 Reservoir. A flow of one half (1/2) the PMF, 975 cfs for this watershed, may be used as a design storm flood for emergency spillway design of intermediate reservoirs with a significant risk hazard. In comparison, a 100-year return period, 24-hour duration storm will produce a peak runoff of about 900 cfs.

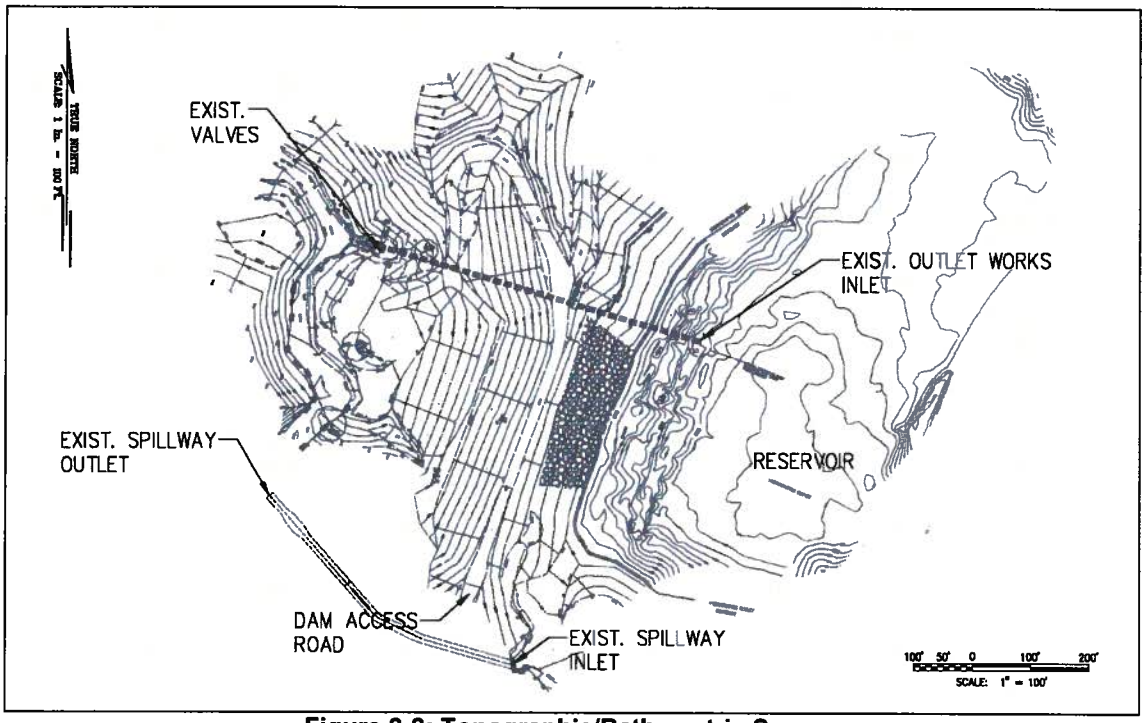

Figure 2-2: Topographic/Bathymetric Survey

3.0 Existing Facilities

The Opaeula 1 Reservoir Dam is impounded by an earthen dam to the west and an inlet channel to the east. The reservoir level is controlled by outlet works and a spillway tunnel located at the dam. The reservoir is approximately 1,100 feet long and 450 feet wide. It covers an area of approximately 6.5 acres at full stage. Operating depth is normally between 58 and 60 feet. The maximum reservoir impoundment volume is estimated at 400 acre-feet. Normal storage is estimated at 258 acre-feet. The outlet works capacity is unknown. For a map of existing features near the dam see Figure 2-2. Photos of the dam and reservoir can be seen in Appendix C. Following are descriptions of the existing facilities for the Opaeula 1 Reservoir.

3.1. Dam Description

The dam is an earth fill structure with a crest length of approximately 250 feet and a crest height varying from 20 to 71 feet. The dam has a crest width which varies from 10 to 15 feet. The upstream slope of the dam was constructed at a slope gradient of about 2:1 (horizontal to vertical) and is lined with riprap. The downstream slope was constructed at slope gradients ranging from 1-1/2:1 to 2:1, with the steeper portions nearest the crest. A generalized cross section of the dam is presented in Figure 3-1.

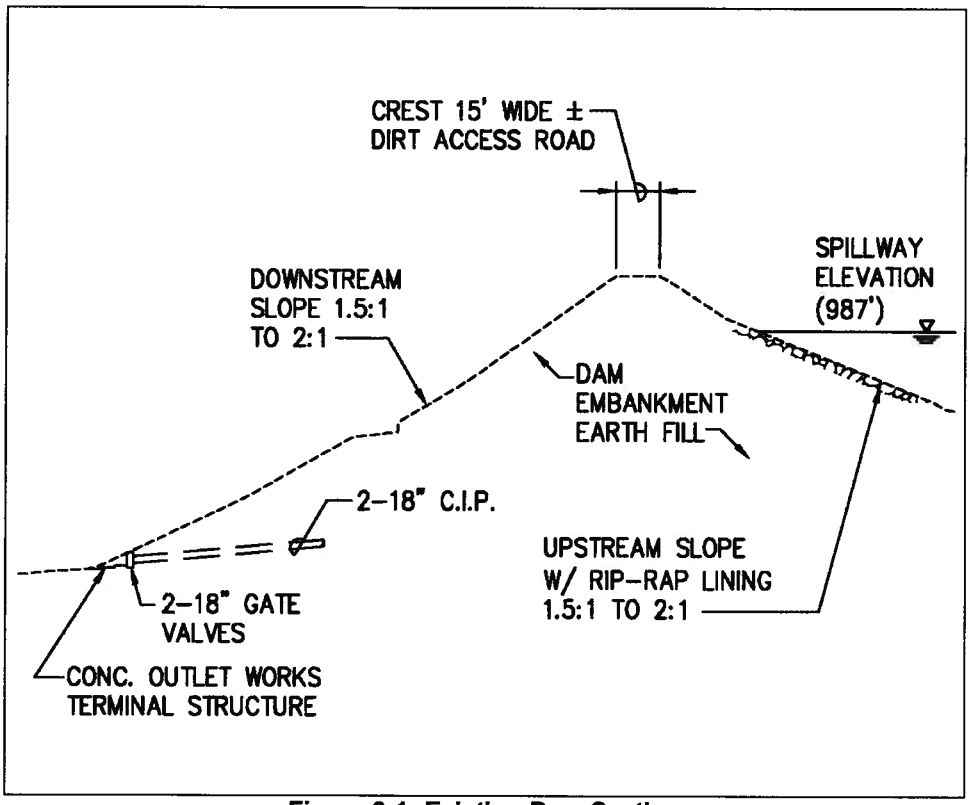

Figure 3-1: Existing Dam Section

3.2. Spillway

The spillway, located on the south side of the dam, consists of a concrete arched tunnel with a width of about 7 feet, a height of about 9 feet, and a length of about 280 feet. The spillway invert is located at an elevation of 987 ft according to the January 2007 survey. The spillway tunnel is used to pass normal and storm flows. In 2006, the spillway was repaired and lined with concrete after a routine maintenance inspection identified a collapsed 20-foot section of the existing spillway tunnel. The discharge flow from the spillway tunnel exits in a high waterfall (about 40 to 50 feet) to a pool below. The capacity of the existing concrete-lined spillway tunnel is approximately 588 cfs, allowing for four feet of freeboard to the dam crest. Spillway tunnel capacity calculations are presented in Appendix B.

3.3. Inlet/Outlet Works

The outlet works consist of two 18-inch cast iron pipes, two inoperable control gate valves, one operable gate valve, and a concrete outlet structure. During the time of inspection, one of the two inoperable control gate valves was stuck in the open position. After the inspection, a new gate valve was installed just downstream of the control gate valve stuck in the open position. A photograph of the concrete outlet structure, cast iron pipes, and gate valves can be seen in Appendix C. The intake portion of the outlet works was submerged and could not be inspected. A terminal structure consisting of three concrete steps dissipates the flow energy between the pipe outlets and the natural streambed.

The inlet works consist of an open channel 91 inches wide and 64 inches deep, which discharges into the drainage basin of the reservoir near its eastern end. Before the ditch empties into the reservoir, it tunnels through a ridge that separates the Opaeula reservoir

drainage basin from the adjacent valley. A throw-out channel is located at the entrance to this tunnel. The throw-out channel was operated with weir boards, but it is now fully open. Currently, there are no boards on-site to block the main channel and divert water to the throw-out channel and away from the Opaeula 1 Reservoir. Photos of these structures can be seen in Appendix C.

4.0 Recommendations

The objective of this project is to improve the operational and safety characteristics of the dam. The improvements will be done to meet the minimum design standards in accordance with the current Hawaii State Dam Safety Regulations addressing the operations and structural integrity of the dam. The spillway capacity of the dam will be improved to handle the required storm event peak flows. The hydraulic controls of the dam will be upgraded to provide safer operation and improved control of water flowing in and out of the reservoir. The dam stability will be improved with the use of an earth buttress.

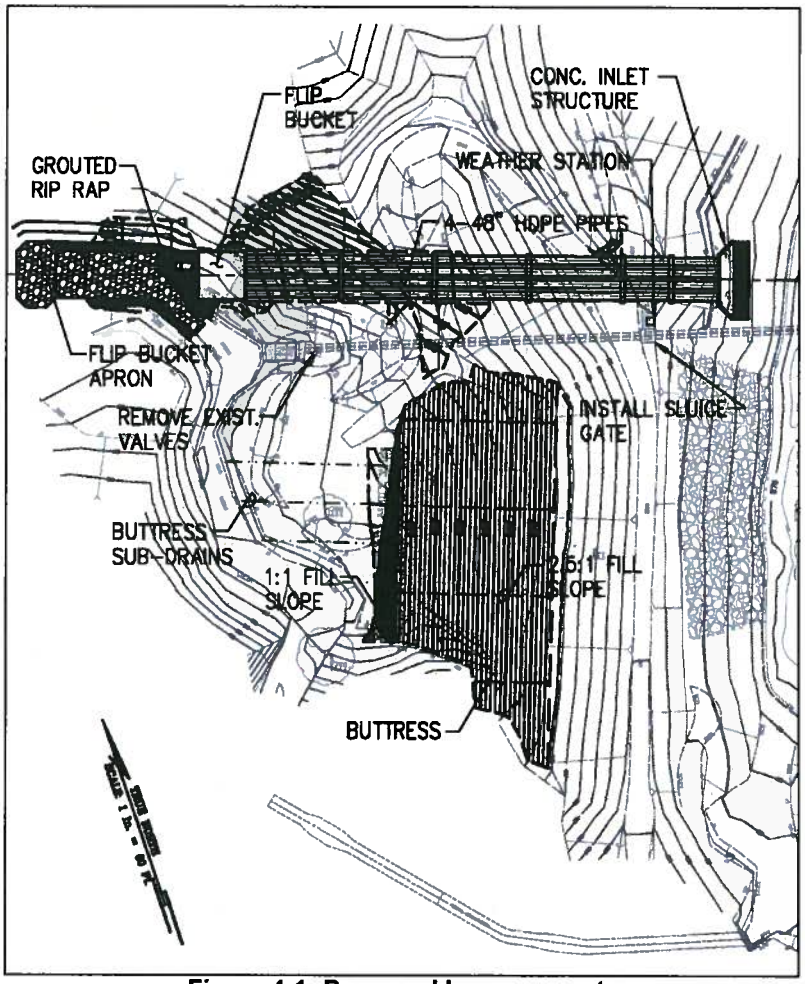

Figure 4-1: Proposed Improvements

4.1. Spillway Design

The proposed spillway will be located on the north side of the dam buttress. The spillway will consist of approximately 244 lineal feet of four 48-inch outside diameter (O.D.) high density polyethylene (HDPE) pipes buried inside the dam abutment, parallel to the existing outlet works. The four pipes will be encased in concrete. For the proposed improvement

layout, see Figure 4-1. The proposed spillway will work in conjunction with the existing tunnel spillway to convey a design storm flow (1/2 PMF) of 975 cfs. The invert of the proposed spillway will be set at elevation 983 ft, and the invert of the existing spillway is at 987 ft. As the water surface exceeds the top of the proposed spillway pipes which is set at 986.5 ft, water will begin to flow through the existing spillway when the water level hits 987 ft. The proposed and existing spillways will convey about 664 cfs and 311 cfs, respectively. The maximum headwater elevation, during the design storm, will be 994.4 ft. The minimum dam crest elevation is 998.3 ft. See Appendix B for detailed calculations.

During the analysis and design of the spillway, the reservoir was classified as "significant" hazard; thus, half of the probable maximum precipitation (PMP) was conducted to assess spillway capacity requirements. After the design of the spillway was completed, the reservoir's classification was changed to "high" hazard. A separate analysis was conducted to show that the capacity of the proposed spillway, which was designed for half PMF, could convey the full PMF. See Appendix C for the analysis.

The inlet structure of the spillway will be a concrete headwall with a riprap apron and beveled pipe entrances to minimize entrance losses into the spillway. The interior of the HDPE pipes will be smooth and have a roughness coefficient (n-value) of 0.010. The vertical alignment of the spillway will have a maximum slope of 30% with a maximum velocity of 53 feet per second (fps) at a flow of 664 cfs. See Appendix B for detailed calculations. To mitigate high velocities at the spillway outlet, a concrete flip bucket will be constructed at the spillway outlet followed by a boulder riprap apron, which discharging flows will impact before flowing into the existing streambed. The length of the riprap apron will be approximately 92 feet. See Appendix B for the trajectory calculations.

The flip bucket will be reinforced concrete (Figure 4-2). It will redirect the water jet into an upward trajectory causing the water to impact the boulder riprap apron below the lip of the bucket, dissipating the kinetic energy of the water. The riprap apron is approximately 92 ft long. PVC drain pipes in the side wall of the flip bucket will eliminate ponding when not in use. See Appendix B for calculations for flip bucket trajectory.

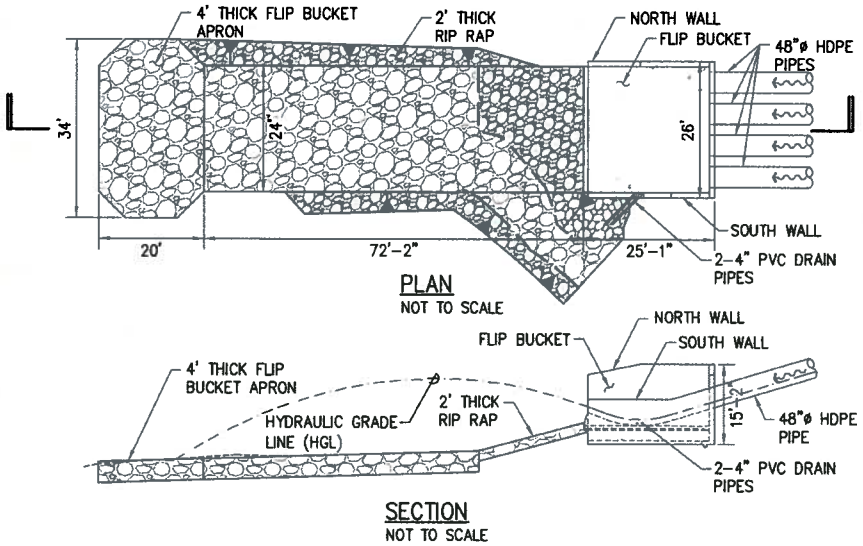

Figure 4-2: Proposed Flip Bucket and Apron

4.2. Dam Buttress Design

In the geotechnical report by YKE, an earth buttress constructed on the dam downslope face is recommended to increase dam stability. A 35-foot tall, 120-foot long earth buttress with a 2.5H:1V slope and a 15-foot wide bench at the top shall be constructed on the downstream slope of the existing dam embankment (Figure 4-3). The buttress will begin at the existing bench and end below the existing toe of slope. The embankment will consist mostly of on-site excess graded and excavated soil and loose rock. The buttress embankment will be benched with benches not to exceed 2 ft in height. A minimum 6-inch thick gravel drainage layer will be placed below the earth fill. A 4-inch perforated PVC drain pipe running parallel to the toe will be used beneath the base of the buttress toe to provide seepage control.

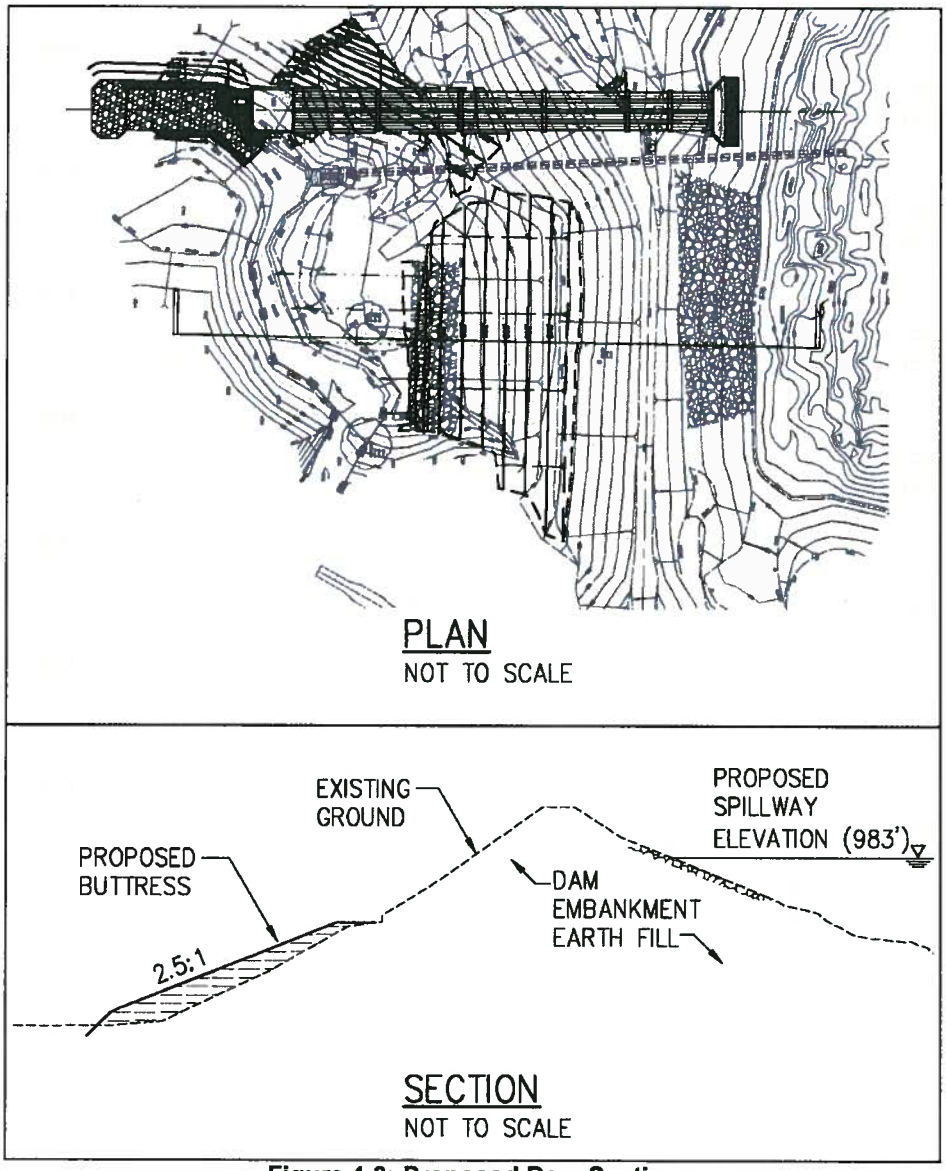

Figure 4-3: Proposed Dam Section

4.3. Outlet Works Modification

The existing outlet works are two 18-inch diameter cast iron pipes buried in the right side of the dam. The outlet pipes will be slip lined to extend the service life of the pipes without replacing them.

The vault box located on the northern side of the access road across the dam will have the concrete covering the 18-inch diameter pipes chipped away to expose the pipes. The pipes will be cut and a sluice gate will be installed at this location to control the flow from the reservoir. The vault will function as a wet well. Gate valves are currently located at the end of the outlet pipes. The existing valves will be removed.

4.4. Inlet Works Modification

The Opaeula Ditch Tunnel feeds the Opeaula 1 Reservoir. During a large storm event, the inflow from this ditch will result in a higher peak flow than would occur from the localized drainage watershed alone. To control the water level in the reservoir and control storm surges, the flow of water entering the reservoir can be diverted at the existing throw-out once the throw-out has been reconstructed.

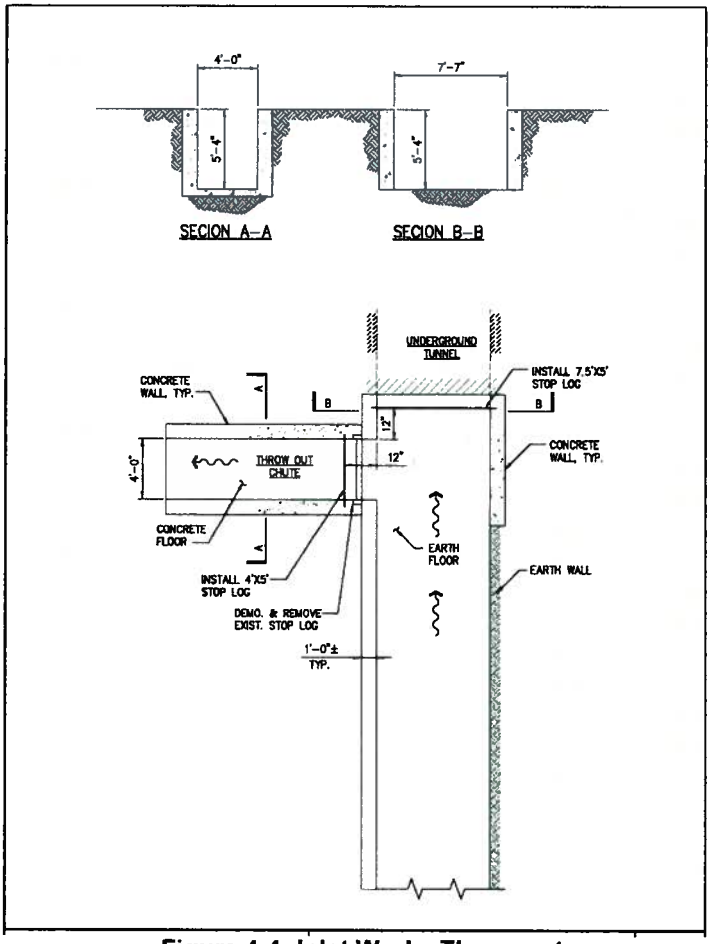

Figure 4-4: Inlet Works Throw-out

Removable stop logs will be installed at the main ditch channel and at the throw-out channel (Figure 4-4). With the stop logs in place at the main channel and removed from the throw-out channel it will be possible to divert the water into the throw-out channel which empties into a nearby gulch. However, under normal conditions, the stop logs will be in place and blocking the throw-out channel with the main channel fully opened to keep water flowing to the Opaeula 1 Reservoir. See Figure 4-5 for the location of the throw-out channel.

4.5. Dam Instrumentation

Four groundwater monitoring wells will be installed within the dam embankment. Two of the wells will be installed at the crest and two will be installed midslope on the downstream side of the embankment. These wells will be used to monitor the level of groundwater beneath the embankment.

A water level piezometer will be installed on the upstream side of the dam embankment to monitor the water levels in the dam.

An array of survey monuments will be installed at selected locations along the crest of the dam, near the downstream slope buttress bench, near midslope of the proposed buttress and at several points offset downstream from the toe of the proposed buttress fill limits. The survey monuments will be used for monitoring surface settlements of the dam and embankment.

A weather station will be located on-site. It will be used to gather and transmit meteorological and monitoring sensor data.

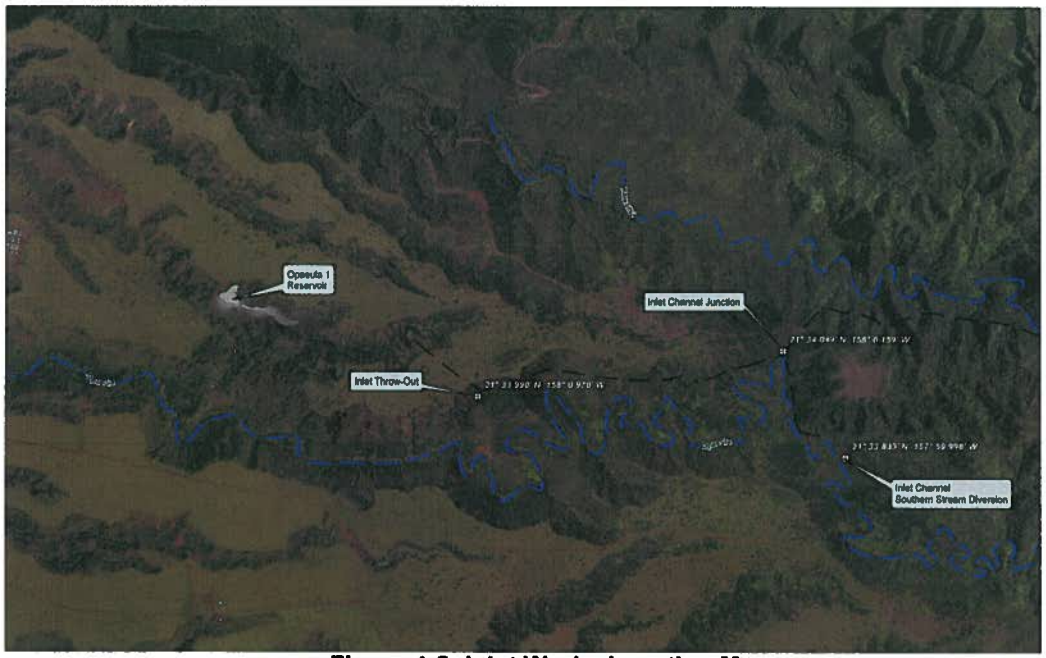

Figure 4-5: Inlet Works Location Map

4.6. Construction Cost Estimate

The estimated cost of construction is $2,060,000.00 for the proposed improvement to the Opaeula 1 Reservoir Dam.